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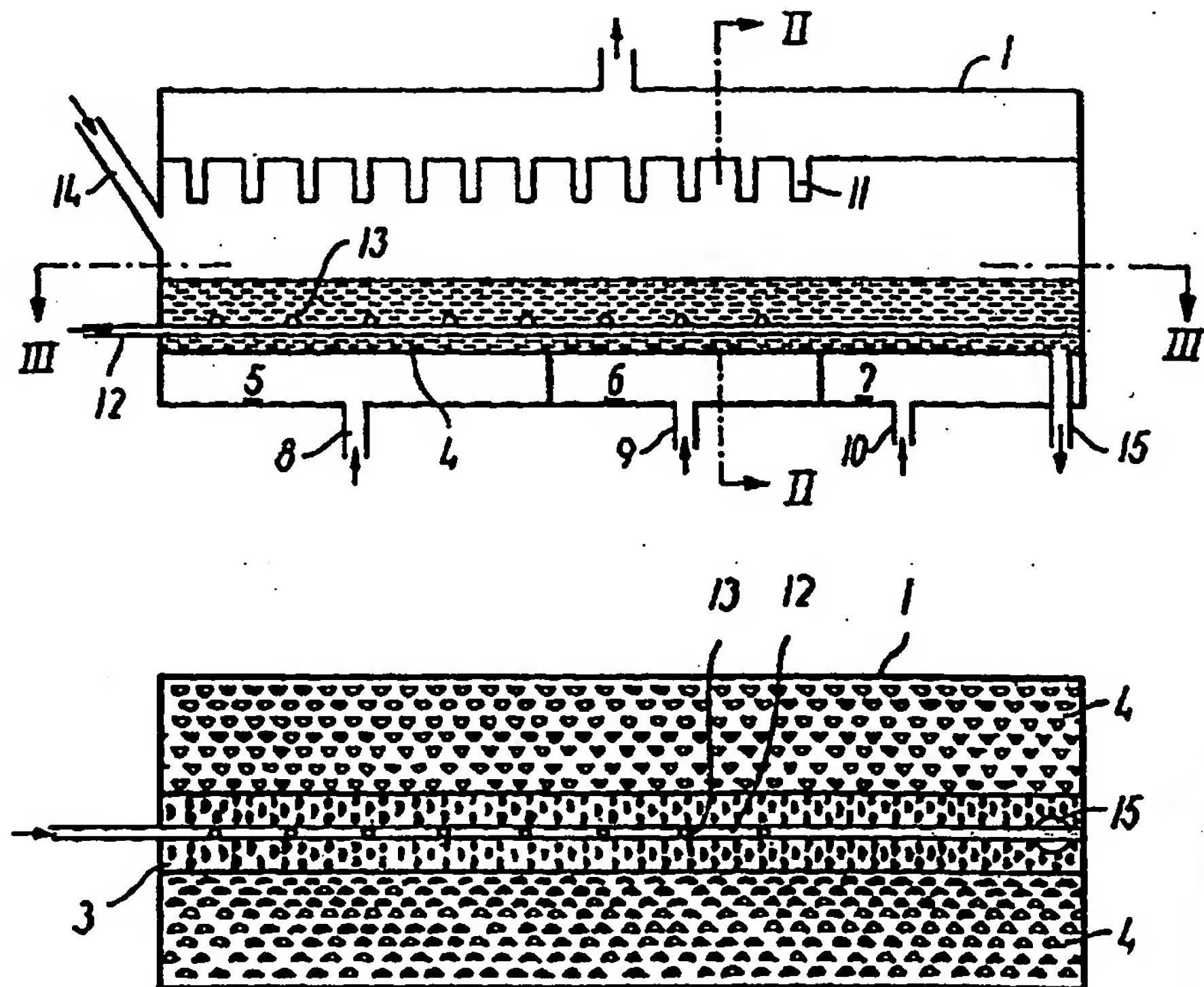
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(54) Title: AN APPARATUS AND A PROCESS FOR THE PREPARATION OF AN AGGLOMERATED MATERIAL

(57) Abstract

An apparatus for the preparation of an agglomerated material from a powder or a liquid or both and having a trough-shaped fluidizing path, in the bottom part of which fluidization gas is blown in with an essential component directed towards the centre line of the bottom of the path, gives a very advantageous material flow, which makes an effective agglomeration possible under attainment of superior product properties. The apparatus makes it possible by a process according to the invention to carry through the agglomeration with a particularly big powder humidity and a subsequent low rehumidification.



## AN APPARATUS AND A PROCESS FOR THE PREPARATION OF AN AGGLOMERATED MATERIAL

The invention relates to an apparatus for the preparation of an agglomerated material from a powder or a liquid or both and a process for such an agglomeration by use of the apparatus.

An increasing and widespread interest in the agglomeration of powdery materials exist within a large number of industries including the chemical and pharmaceutical industries not to mention the food industry.

There may be many reasons why it is desirable to transform a powdery material consisting of fine particles into a product consisting of relatively big, preferably homogenous agglomerates. As examples of such reasons may be mentioned the attainment of dust-elimination, free flowing property and a desired appearance as well, in particular in respect of foodstuff and feeding stuff products, the attainment of a good reconstitution ability, i.e. the ability to, without any essential mechanical stirring, quickly regenerate a liquid product corresponding to the one, on basis of which the powdery product was originally prepared. This ability to easily reconstitute is dependent on the ability of the material, when in contact with a liquid, to disperse, to be humidified and to dissolve, and particularly in respect of the dispersibility of powdery foodstuff and feeding stuff comparatively big homogenous agglomerates are desirable.

Various different processes and apparatuses are known for agglomerating powdery materials either in connection with the production thereof or as a subsequent processing step.

Processes of this type will in connection with an atomization drying typically result in fine particles formed by the atomization drying being brought back to the atomization zone thereby getting in contact with atomized droplets, or only partially dried and therefore tacky

effective fluidization of the material is secured by means of the fluidizing ability inherent in the bed in question.

The fluidized powder will then by passing a number of successive nozzles and intermediary areas without nozzles 5 alternatingly be humidified for the attainment of an agglomeration-enhancing moisture content and then dried to ensure the fluidizability of the powdery material and for stabilizing the attained agglomerated before passing the next nozzle, where a re-humidification takes place, then 10 agglomeration again and renewed drying, which cycle is typically repeated several times.

On account of the limited fluidization ability of the known agglomeration apparatus it has in such processes been necessary to carry out a substantial drying of the powder 15 during and between its passing the nozzles. This has, however, entailed that the demand to re-humidification at the individual nozzle passages has increased in order to attain for a short period the necessary moisture content for the agglomeation, the material of the individual 20 agglomerates being during the passage through the fluidized bed exposed to a number of fairly extensive re-humidifying and drying steps.

These extensive re-humidification and drying steps have, however, in respect of many materials, an undesirable 25 influence on the quality of the resulting product.

Thus, if fatty food products, such as whole milk powder, fatty whey products, calves forage, babyfood and the like are processed, these steps will result in an increased amount of the fat of the product reaching the 30 surface of the particles, which results in the content of so-called free fat becoming too big, whereby its ability to be humidified by water becomes too small, and in the worst case an increase of the risk of fat drops forming when stirred into water occurs.

Moreover, these re-humidification steps, which due to 35 the fact that the intermediate drying steps are to be carried through for the attainment or the maintenance of an

size possible, as these particles, which will appear from below, pass the apparatus in a path, which is to a great extent independent from the particle size.

The last-named property of the apparatus in combination with the very strong movement, to which the material to be processed is exposed in the apparatus, makes it suitable for treatments, in which also a mixing of different components takes place.

Other advantages of the apparatus according to the invention will appear from the following description.

According to the above the invention relates to an apparatus for the preparation of an agglomerated material from a powder or a liquid or both and comprises a perforated plate and means to provide through its perforations a flow of fluidizing and drying gas and possibly cooling gas, sufficient for keeping a powdery material in a fluidized state in a zone immediately above the plate, outlets for agglomerated material and at least one nozzle for spraying an atomized liquid on the fluidized powder, which apparatus is characteristic in that the perforated plate is designed in such a way that it together with non-perforated side walls forms a trough-shaped path leading to said outlets; the perforated plate forming the bottom of the trough-shaped path, and in that a substantial part of the perforations of the perforated plate is directed such that the fluidizing gas and the drying or cooling gas after passage through each of these flow in a direction parallel with the longitudinal direction of the trough-shaped path and towards the outlets for agglomerated material or in a direction perpendicular thereto towards a centre line in the path or in a direction between these two directions, the gas flow from the perforations being adapted to co-operate for the attainment of a conveyance of material to the outlets through the trough-shaped path, where the material during its conveyance along the path is whirled upwards above its centre line and flows down along the side walls.

possible by the conventional apparatuses.

By working with such an increased moisture content, the drawbacks related to a heavy re-humidification can to an essential degree be avoided, cf. the above.

5 The perforated plate at the bottom of the trough-shaped path may be designed in many ways. Preferably, it comprises a lower part which is a substantially horizontally perforated plate extending centrally throughout the length of the apparatus, and two oblique  
10 perforated plates extending on either side of the horizontal plate and connecting the latter with the two non-perforated side walls.

Alternatively, the perforated plate is constituted by a plate with a curved cross-section profile connecting the  
15 two non-perforated side walls.

It is, however, also possible by means of the directionally controlled blowing in of the fluidizing air through the perforated plate to attain the desired flow pattern, for which reason the perforated plate may be only  
20 a horizontal plate extending between the two non-perforated side walls.

In a preferred embodiment of the apparatus according to the invention the nozzle/nozzles which is/are used for spraying liquid on to the powdery material are positioned  
25 centrally in the very zone, in which the fluidized material is present during the operation of the apparatus, and is upwardly directed. Hereby is achieved partly that the nozzles to an extensive degree are kept clean from the upwards flow of powder and gas, partly that the nozzles  
30 contribute to the desired whirl movement, in particular in case of two-component nozzles, such being preferred, when the atomization pressure air emanating from the nozzles enhances the upward flow around the nozzles.

The nozzles are intended, when the starting material  
35 is a powder, to supply an auxiliary liquid enhancing the agglomeration and perhaps enhancing the attainment of further desired properties of the product, for instance by

question.

The invention is described in detail in the following with reference to the drawing, in which

Fig. 1 is a schematic cross-sectional view of an embodiment of an apparatus according to the invention,

Fig. 2 is a schematic cross-sectional view through the same embodiment along the line II-II of Fig. 1,

Fig. 3 is a schematic horizontal view seen from above through the same embodiment, taken along the line III-III 10 of Fig. 1, and

Fig. 4 schematically shows a sectional view of another embodiment of a part of the apparatus corresponding to the one shown in Fig. 3.

In Figs. 1-3 a sectional view of an embodiment of an apparatus according to the invention is shown with a housing 1, in which a perforated air distributing plate 2 is provided, said plate in the embodiment shown being constituted by a horizontal plane section 3 and two oblique plane sections 4.

The perforations are in the embodiment shown so-called gill slits designed for instance as described in EP-A-474949.

As an alternative to the design of the air distributing plate 2 it may be designed as a plate evenly curved around its longitudinal axis, or it may, less preferred, be plane.

Below this plate a plenum chamber is provided, said chamber being divided in sections 5, 6, 7 by partition walls, to which through the ducts 8, 9, 10 fluidizing gas 30 is supplied, for instance hot drying air through the ducts 8 and 9 and unheated cooling air through the duct 10.

Above the air distributing plate 2 a row of filters 11 are provided in the embodiment shown, through which filters the leaving gas flow passes in such a way that the fine particles entrained therewith are separated and fall back on the central part or the front part of the perforated plate.

openings in the two oblique sections 4 is, however, directed perpendicularly thereto and is in respect of each section 4 directed towards the centre line of the air distributing plate. The gas from the two sections 4 will 5 thus substantially impart a movement pattern to the powder introduced like the one shown in Fig., 2, whereas the gas departing through the openings in the horizontal section 2 ensures the conveyance of the material longitudinally through the apparatus. This combination is considered 10 particularly advantageous as big agglomerates and lumps, if any, will fall down towards section 3 and will there be subjected to a quick conveyance towards the outlet means 15 in such a way that they quickly leave the apparatus without participating in any further formation of agglomerate.

15 Alternatively, the orientation of the openings of the plate may be identical within each half of the plate, the gas being substantially directed towards the centre line of the plate, but with some component towards the outlets.

When the powdery material in the trough-shaped path 20 formed by the air distributing plate 2 and side walls 16 performs the whirl movement shown in Fig. 2, it will during the upwards movement in the central part be subjected to a very homogenous moisturing from the liquid atomized from the nozzles 13.

25 This fact that the moisturing may be performed very homogeneously with only a slight risk of local over-moisturing results in that during operation of the apparatus it becomes possible to work with a powder moisture content close to the maximum acceptable level, 30 said level being besides very high on account of the particularly good fluidization properties of the apparatus.

This has the effect that the powdery material may either be introduced with big humidity, or operation may be carried out with such a low drying capacity of the 35 fluidization air that a big powder moisture is maintained/attained in the agglomeration phase, and only a supply of a fairly small amount of liquid is required for

that the agglomerates may be obtained with a desired physical strength which allows handling and transport without decomposition, the binding together of the individual particles being at the same time not so strong  
5 that their disintegration during reconstitution in the liquid phase is delayed or hindered.

The good fluidization properties of the apparatus and the movement of pattern for the material therein, which is characteristic in two partially united, parallel helical  
10 paths extending in the longitudinal direction of the apparatus, ensure a good mixing of the material, the movement through the apparatus, seen in the longitudinal direction, being simultaneously essentially a plug flow without essential back flow, in such a way that the good  
15 mixing properties of the apparatus are not attained at the expense of the advantages in respect of a homogenous treatment caused by the plug flow.

The liquid atomized through the nozzles 13 may be water, where this is sufficient for imparting a sufficient  
20 mutual adhesion to the powdery particles. However, the liquid fluidized through said nozzles may also be a solution, a suspension or an emulsion, at the drying of which compounds remain, which further the formation of agglomerates or impart the necessary strength thereto or  
25 which form a coating on the particles present in the apparatus for improving their properties, such as is known within many industries, including the pharmaceutical industry and the detergent industry. The coating may either be carried out with the same compound, of which the  
30 particles or part of these are constituted, or it may be formed by means of an auxiliary compound of another type, for instance with a film-forming polymer.

Typically, but not necessary, such a coating operation may take place in the lower part of the  
35 apparatus, with respect to the flow direction of the material.

If the liquid supplied through the nozzles is a

paths, said paths each having an end extending under said bottom section of the atomization drying chamber for direct receipt of powdery material therefrom. The fluidization gas, which leaves this fluidized bed, may in this case be 5 recovered together with the used atomization drying gas from the atomization drying chamber, but it may, in order to avoid introducing the relatively cool fluidization gas in the chamber, be advantageous to use a separate outlet for the fluidization gas.

10 The invention is described in detail with reference to the following examples.

#### Example 1

In this example an apparatus according to the 15 invention was used, in which the perforated plate was substantially horizontal but had upwardly bent edges united with the nearly vertical side walls of the trough-shaped path. The width of the perforated plate was 32 cm, and the total length of the trough-shaped path comprising 20 six plate units was 15 m, divided into a first section of 2.5 m, a second section of 5 m, and a third section of 7.5 m.

The perforations of the plate were so-called gill slits, which were all directed towards the centre line of 25 the perforated plate with a small component in the longitudinal direction of the path towards the outlet for finished agglomerate.

A fatty milk substitute consisting of a mixture of a number of different ingredients was used as starting 30 material.

The particle size distribution of this starting material was as follows:

% < 75 um:	34	$d_{10}$ : 10% < 30 um
% < 150 um:	66	$d_{50}$ : 50% < 105 um
35 % < 250 um:	87	$d_{90}$ : 90% < 265 um
% < 425 um:	100	
% < 600 um:	100	span : $(d_{90} - d_{10}) / d_{50} = 2.24$

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particle size distribution, which would be expressed in that the span-value would typically be 2.0 or more.

#### Example 2

5 The same apparatus as the one described in Example 1 was used, and the starting material was also here a fatty milk substitute, and the agglomeration liquid was water.

For agglomeration of 1500 kg/hour starting material 165 kg/hour water was sprayed on corresponding to 11% of 10 the starting material.

The inlet temperature of the fluidizing gas was 60°C, and the powder temperture through the plant was in the range of 30°C to 35°C.

15 The particle size distribution of the end material was determined after the passage of the material through the first section, after its passage through the second section and in the end product.

The results were as follows:

	Starting material	Section 1	Section 1	End product
20				
$d_{90}$ : 90% < d, $\mu\text{m}$	255	475	532	653
$d_{50}$ : 50% < d, $\mu\text{m}$	93	230	291	380
25 $d_{10}$ : 10% < d, $\mu\text{m}$	26	72	109	174
Span =				
$(d_{90}-d_{10})/d_{50}$	2.46	1.76	1.45	1.26

It appears from these results that the agglomeration 30 taking place during the passage of the material through the apparatus does not only entail a quite considerable increase of the average particle size but also that during this pasage a desired narrowing of the particle size distribution occurs.

apparatus, and two oblique perforated plates (4) extending on either side of the horizontal plate (3) and connecting the latter with the two non-perforated side walls (16).

4. An apparatus according to claim 1, characterized in that the perforated plate is a plate having a curved cross-section profile connecting the two non-perforated side walls (16).

5. An apparatus according to claim 1, characterized in that the perforated plate is a horizontal plate extending between the two non-perforated side walls (16).

6. An apparatus according to claim 1, characterized in that said at least one nozzle is positioned in the centre plane of the trough-shaped path and in the zone, in which the fluidized material is present during the operation of the apparatus, and in that it is directed upwards.

7. An apparatus according to claim 6, characterized in that said at least one nozzle consists of a number of two-component nozzles (13).

8. An apparatus according to claim 3, characterized in that the perforations of the horizontal plate (3) are directed in such a way that they supply fluidization gas completely or substantially in a direction parallel to the centre line of the trough-shaped path and towards the outlet means (15), whereas the perforations of the oblique perforated plates (4) are directed in such a way that they supply gas completely or substantially in directions perpendicular to the centre line.

9. An apparatus according to any of the preceding claims, characterized in that it comprises a number of paths put parallelly together, each path comprising a perforated plate, which paths are mutually separated by vertical or steeply slanting sidewalls and connected in series for passage therethrough of powder or agglomerates.

10. An apparatus according to any of the claims 1-8, characterized in comprising an atomization

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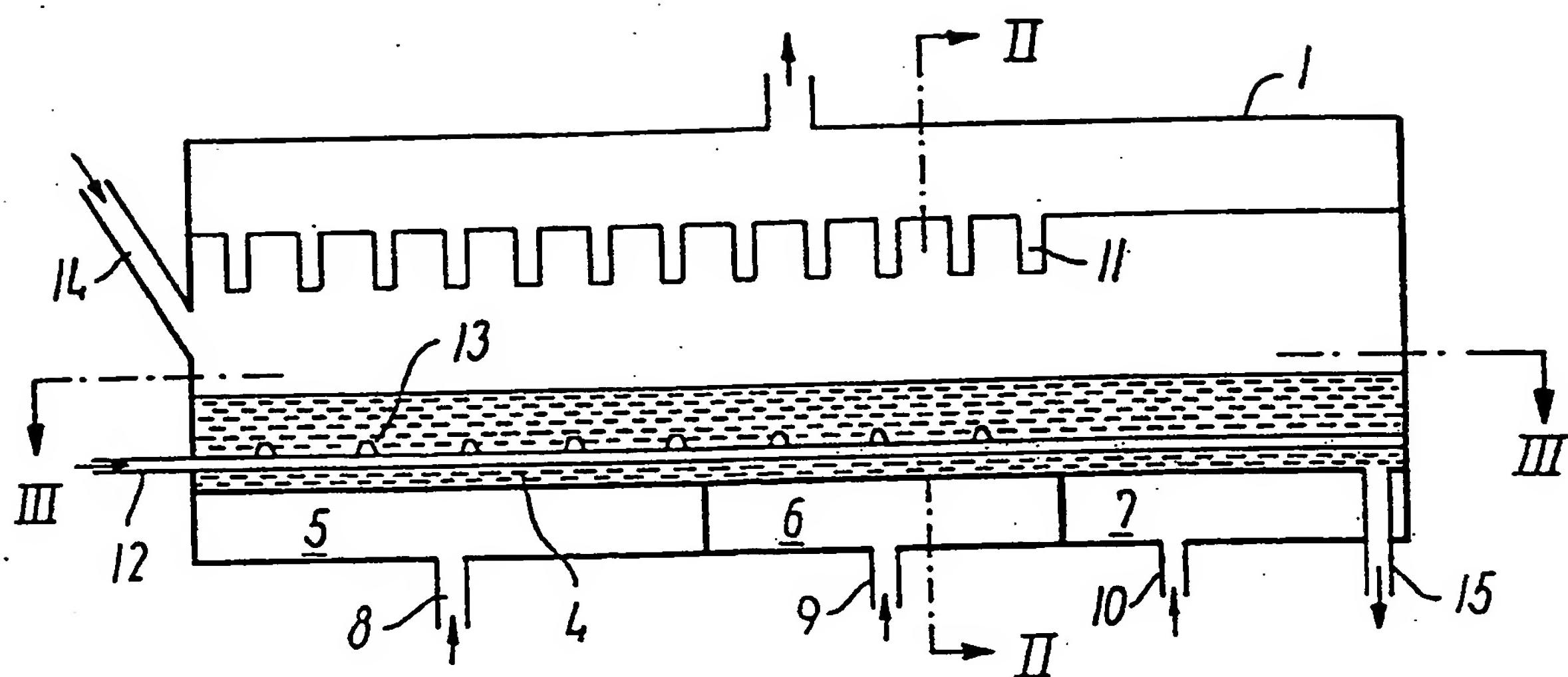


FIG.1

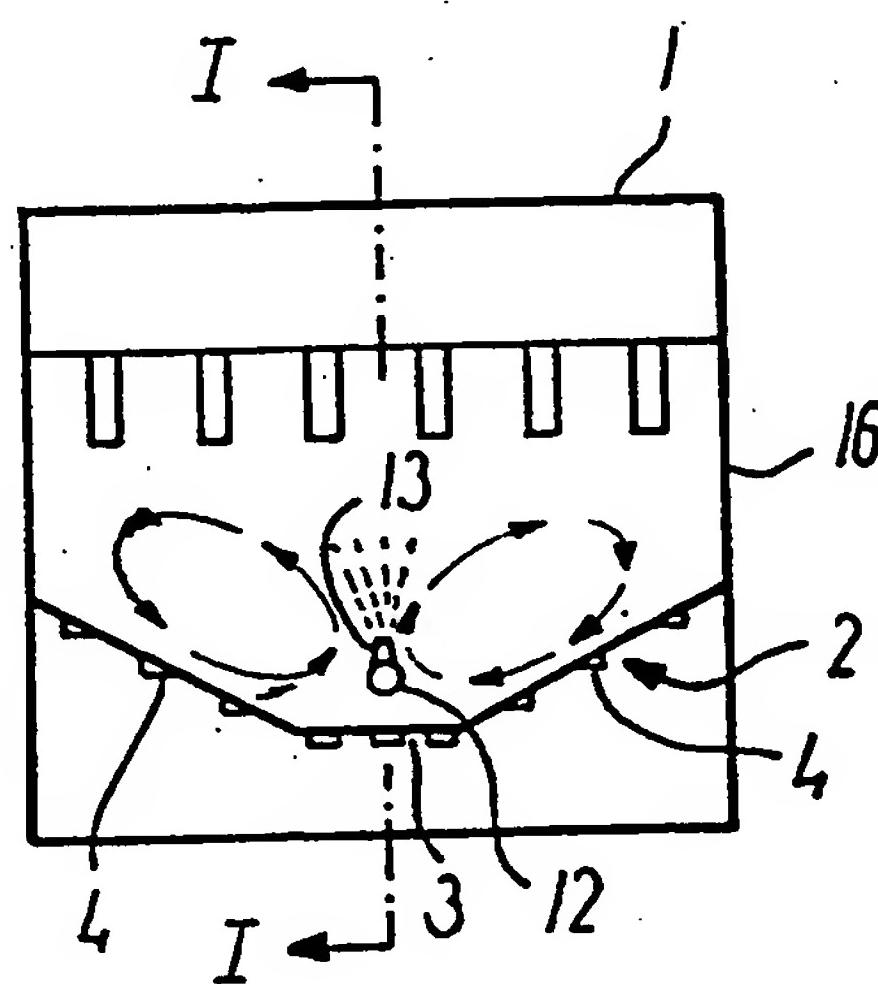


FIG.2

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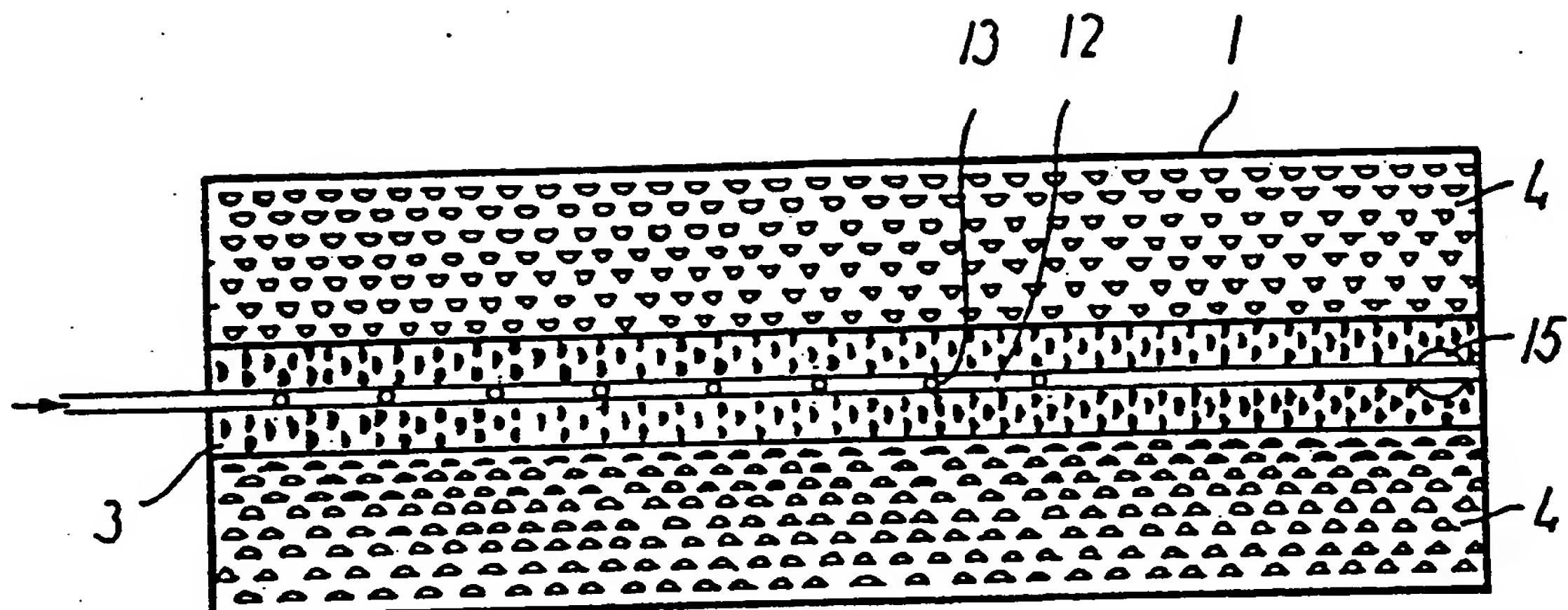


FIG. 3

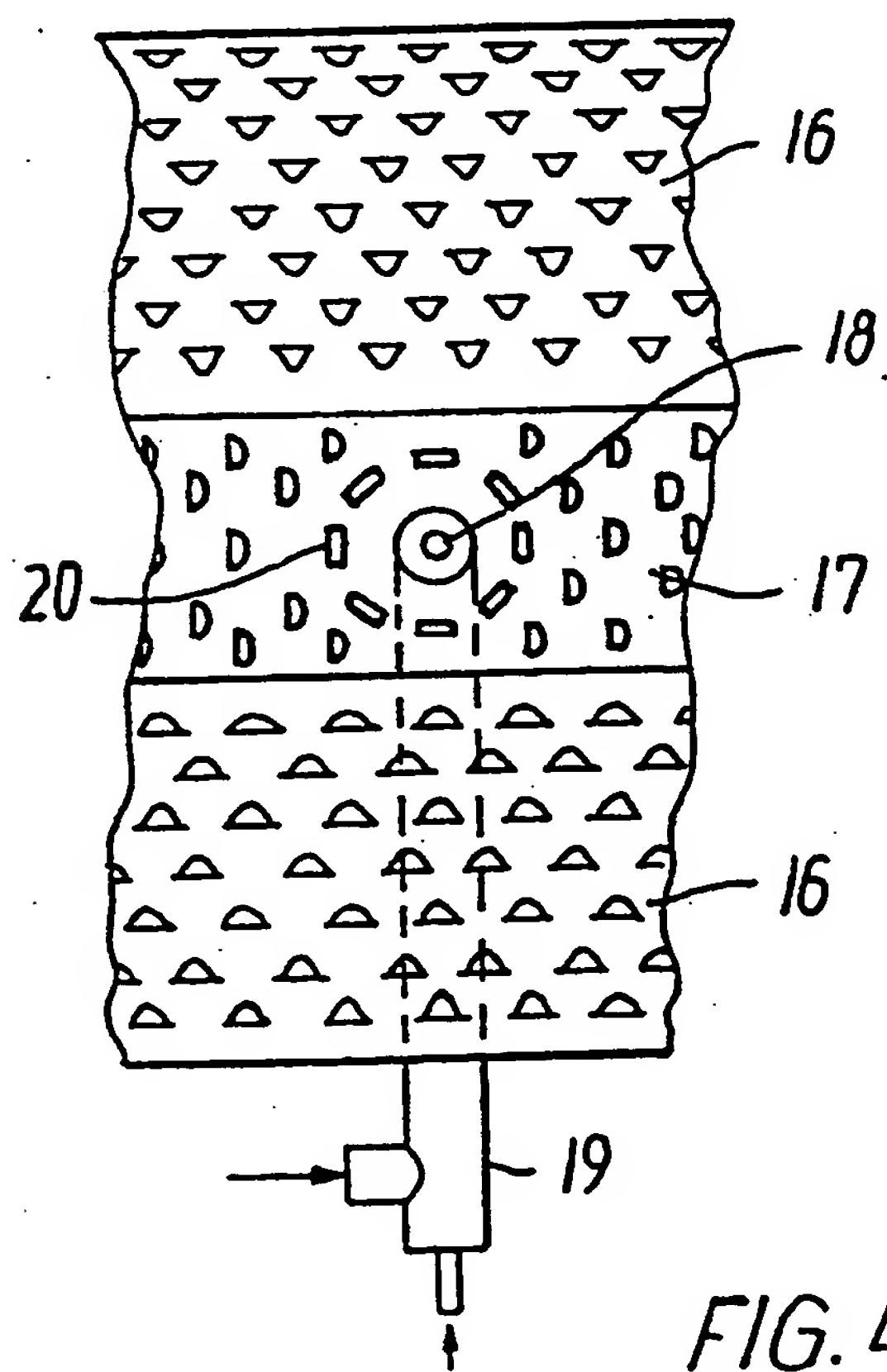


FIG. 4